4.1 HYDROLOGY: PRECIPITATION AND FLOW

While last year's El Niño season produced twice as much rainfall as normal, the rebound effect from this year's La Niña season produced less than half the normal rainfall. Sixteen storms were sampled during the season, compared to 29 last season. This year's wet season rainfall was only 6.81 inches at the downtown Los Angeles gage with the bulk of the rain falling in April, as compared to over 33 inches of rainfall last season. In addition, for the month of February, this season's total rainfall was only 0.40 inches compared to 15.24 inches last year. Similarly, the total rainfall for the 1998-1999 season at the Ballona Creek station was only 9.48 inches and the total wet season runoff volume at the Ballona Creek station was 10,700 acre-ft. By comparison, the rainfall total last storm season at this station was 28.28 inches and the runoff volume was 18,300 acre-feet.

Table 4-1 summarizes the hydrologic and meteorologic conditions of each station-event monitored this season, while Table 4-2 summarizes the hydrological data for each station for the 1994-95, 1996-97, 1997-98, and 1998-99 seasons. These data will help define hydrologic and water quality trends after subsequent years of data are compiled. A collection of 1998-99 season hydrographs for each storm event from the monitored sites and rainfall contour maps is included in Appendix B. Each hydrograph includes the time of grab sample collection when applicable, the time of the first and last composite sample aliquot collection, the number of aliquots per composite, the sample volume interval, and the percent of storm sampled.

Also included in Appendix B are contour maps of total rainfall for the 1994-95, 1995-96, 1996-97, and 1997-98 storm seasons. The dates given as "Storm Event Date" are the dates each storm began.

4.2 STORMWATER QUALITY

A summary of the composite and grab samples taken during the 1998-99 season is included as Table 4-3.

4.2.1 Determination of Constituents of Concern for Analysis

The County analyzes for some 209 individual water quality constituents, the results of which are included in Appendix C. But while the Municipal Stormwater permit lists 25 of them as constituents of concern, some constituents were not detected or were detected at levels below a number of common water quality guidelines. Therefore, a comparison was made between mass emission water quality results and the water quality objectives outlined in the Ocean Plan, Basin Plan, and California Toxics Rule. If either the mean or median concentration of a constituent from mass emission sampling exceeded the objective, it was selected for further analysis. Such a comparison was made of the 1998-99 water quality concentrations, and only five pollutants were identified (Table 4-4). The same comparison was then made of the 1997-98 storm season results, which yielded 10 constituents of concern (Table 4-5). Four additional constituents, total suspended solids, diazinon, chlorpyrifos, and bacteria, which may have not exceeded standards or did not have standards defined, were also included. The constituents used for analysis included:

- Dissolved Cadmium
- Dissolved Copper
- Total Copper
- Dissolved Lead
- Total Lead
- Total Mercury
- Dissolved Zinc
- Total Zinc
- Total Suspended Solids
- Cyanide
- Diazinon
- Chlorpyrifos
- Total Coliforms
- Fecal Coliforms
- Fecal Streptococcus
- Fecal Enterococcus
- Bis(2-ethylhexyl)phthalate

The above 17 constituents of concern were used in developing the percentile distribution (box and whisker) graphs, bacteria count trend analysis, and pollutant loading estimations.

There are no numerical water quality standards that apply to stormwater or "non-point source" pollution. Current federal and state numeric standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation or noncompliance with the plans. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the tables are detected values before dilution, a factor allowed by the Ocean Plan. At the same time, however, it should be noted that new stormwater permits are including the narrative guidelines and limitations prescribed in the local Basin Plans.

4.2.2 Mass Emission Element

The NPDES Municipal Stormwater Permit mandates that the County monitor the quality of its stormwater discharges and creates various programs for managing and improving stormwater runoff quality. The permit specifically requires the County to assess the pollutant loading from all six of its Watershed Management Areas following the 1998-99 storm season.

4.2.2.1 GIS Model

To assist in implementing this requirement, the Department developed a GIS application called the Pollutant Loading Model. A brief description of the model follows:

Hardware Requirements

- IBM-compatible, running Windows NT 4.0 or Windows 95
- 8 MB hard disk space (data/project on network); 600MB hard disk space (local)
- 64 MB RAM or higher

Software Requirements

- ArcView 3.1
- Spatial Analyst 1.1 for ArcView

Data Requirements

Geographic -

- Thomas Brothers Maps® data sets, County of Los Angeles
- SCAG Land Use
- Watershed Management Area Boundaries
- Rain Gages
- Drains
- Watershed sub-basins
- Municipal Boundaries
- Water Quality Monitoring Stations

Tabular -

- Rain gage data for each rainfall event
- Event Mean Concentration data

The Pollutant Loading application computes total pollutant loading for selected pollutants originating in user-defined watersheds or political boundaries. It draws upon many existing data sources, such as predetermined drainage subbasins, land use, historical and event rainfall data, water quality monitoring station results, and multiple underlying geographic data including political boundaries, natural boundaries, census tracts, forest boundaries, streets, and drains.

The user is given the option of hand-digitizing a study area or graphically selecting a predetermined drainage subbasin, monitoring station watershed, city, or other municipal boundary to use as a study area. The user can also locate an area of interest by typing an address or selecting a Thomas Brothers Maps® page.

The user selects a rainfall event from historical records. Rainfall data comes in the form of a previously processed grid of the user-selected storm event or as a rain gage data file, in which case, the model will prepare a rainfall grid using the Spatial Analyst extension. There is also an option to use average annual rainfall.

The application uses the rainfall data to calculate the amount of runoff, based on the imperviousness of the land use polygons it intersects. See equations used at the end of this Section.

The user then has the ability to choose the pollutants for the study from over 257 constituents. The Water Quality data comes from over 24 monitoring stations the County has operated at some point since the 1994-95 storm season. The user can quickly select constituents from pre-classified groups such as General Minerals, Heavy Metals, Pesticides, etc. By default the model will select the 25 pollutants of concern (made up of 61 constituents) listed in the NPDES permit.

The model will then tabulate total pollutant load for the study area using previously calculated Event Mean Concentrations of the selected pollutants. A report of the results is generated in

Crystal Reports. The application also produces maps as ArcView layouts showing the area of study, rainfall isohyets, landuse distribution, rain gage locations and values.

Equations Used

- Runoff Volume = (Rainfall Volume)*(Runoff Coefficient)
  Where:
  Runoff Coefficient = (0.8*Imperviousness) + 0.1
- Load = (Pollutant concentration)*(Runoff Volume)

Assumptions and Limitations

- An imperviousness value used for the calculations is associated with 104 different landuse categories.
- The 104 SCAG land use categories have been aggregated into 34 categories covering 100% of the County.
- Water quality data collected from 8 different landuse monitoring stations yields Event Mean Concentration (EMC) values. The remaining landuse categories (34-8 = 26) use assumed EMC values based on their association with the 8 monitored landuse types.
- All polygons of the same landuse type are assumed to have the same EMC value regardless of their spatial location within the county.
- Annual pollutant loadings use previously calculated seasonal EMCs for their calculation.
- Rainfall grid cell sizes are 500 feet by 500 feet. Rainfall depth does not vary within the grid cell.
- The model does not account for variation over time in soil permeability which influences surface runoff in undeveloped watersheds. In other words, a given coefficient of discharge for a particular land use type will not change regardless of previous soil conditions (saturated soil versus dry soil)

Comparison of Ballona Creek Watershed Observed Loading with Model Results

The Ballona Creek watershed was chosen to compare observed results with modeled results for the purpose of evaluating and adjusting, whenever possible, the model to ensure it behaves as closely as possible to real conditions. In this case, the main parameters to be tested are storm runoff volume and loading of total suspended solids and a few heavy metals. The storm event of April 6, 1999, was chosen.

The primary operations that are inherent to both observed and modeled methods are described below.

ITEM	**OBSERVED METHOD**	**MODEL CALCULATIONS**
STORM RUNOFF VOLUME	Flow rate taken directly from stream gage data and integrated over duration of storm to develop runoff volume. Note that this parameter includes base flow and storm runoff. Calculations can be made to estimate a base flow and separate it from the observed runoff.	Rain gage rainfall depths are used to prepare a rainfall grid surface. Rainfall grid cells are 500' x 500'. Equations: (1) Runoff coeff. = (0.8 x Imperviousness) + 0.1 (2) Rainfall volume = (Rainfall depth) x Area (3) Runoff volume = (Rainfall vol.) x (Runoff coeff.)
POLLUTANT EVENT MEAN CONCENTRATION (EMC)	Flow composited samples obtained at the mass emission monitoring sites are analyzed by the lab. Resulting pollutant concentrations are EMCs.	(1) The entire county is comprised of 34 general land use types. Storm runoff from the 8 most significant types is flow-weight sampled by automated equipment. The monitored watersheds of the eight significant types are chosen to represent typical examples of that land use. (2) Water quality results from the 8 monitored land use stations are assigned to the remaining 26 unmonitored land use types based on similarities of land use. (3) Any given land use type is assumed to yield the same EMC anywhere in the county (i.e. a given polygon defined as Single Family Residential (SFR) is assumed to yield the same EMC as any other SFR polygon in the county).
POLLUTANT LOAD	Observed concentration (EMC) multiplied by observed runoff volume.	Observed and assigned concentrations (EMC) for each land use multiplied by the modeled runoff volume for each land use summed within the area of study.

Runoff Volume Calculations

Runoff volumes were calculated from both the observed mass emission data and the loading model for the storm of April 6, 1999, which produced 0.71" of rain in downtown Los Angeles over a 10 hour period. In downtown Los Angeles, total antecedent rainfall to that day was 4.56". The results are found below.

Watershed	**Total Runoff Volume (ac-ft)**	
	Observed	**Model estimation**
Ballona Creek	2,180	2,950

The modeled runoff volume closely matches what was calculated from the stream gage; the modeled runoff volume is 35% higher than the observed value. This difference may be due to a variety of factors including surface detention on impervious areas and greater infiltration on pervious areas. The overall calculated imperviousness of the watershed is 53%.

Pollutant Load Calculations

Loads for three heavy metals and Total Suspended Solids (TSS) were then calculated from the observed mass emission data and by the loading model at the Ballona Creek Station. The results are summarized below.

Constituent	Loading from observed parameters (lb)	Model estimated loads (lb)
Dissolved Copper	38.0	48.9
Dissolved Zinc	445	780
Total Copper	68.8	78.8
TSS	592,000	441,000

The loading model results for the heavy metals are slightly higher as expected in part because the runoff volume computed by the model is higher. Values of total copper and dissolved copper are within 15% and 29% respectively. TSS computed by the model at Ballona Creek is 26% lower than the loading computed from observed parameters.

Conclusions

Loads are calculated by multiplying the runoff volume by the pollutant concentration. We'll briefly summarize the findings of runoff volume and of pollutant concentrations.

- **Runoff Volume**
  The loading model yields conservative runoff volumes from a small storm. For the Ballona Creek watershed, the modeled runoff volume was 35% above the observed value. As mentioned before, factors influencing the observed runoff volume include detention of flows upstream of monitoring stations. Other factors (especially in undeveloped watersheds) include the variation over time of soil permeability where a storm event of high intensity falling over a saturated soil will yield a higher surface runoff volume than a storm of lower intensity falling over a dry soil.

- **Pollutant Load**
  While load calculations for the observed values use a single EMC per constituent, the loading model uses up to 8 different EMCs based on the land use type. In the case of dissolved copper, the observed EMC is 6.4 µg/l, while the loading model uses various EMCs depending on the land use. The most predominant land use type for Ballona is High Density Single Family which makes up almost 42% of the watershed, and it uses an EMC for this storm event of 8 µg/l.

The model does not take into account possible degradation or adsorption of the pollutant as it is transported downstream. These results therefore should not be taken as absolute; rather, they should be used for unmonitored watersheds or smaller portions of monitored watersheds for comparative purposes only.

4.2.2.2 Mass Emission Water Quality

This section provides a description of wet-weather results generated during the 1998-99 monitoring season (Figure 4-1), followed by a five-year summary of water quality parameters as monitored in the mass emission stations of the Program during wet weather (Figure 4-2). Each figure presents several panels, one for each parameter, with a series of "box-and whisker" plots, one for each station. This "box-and whisker" presentation of the data provides information on the distribution and variability of each data set. It shows the median, mean, 25 and 75 percentiles, 10 and 90 percentiles, as well as the 5 and 95 percentiles. Common water quality objectives for each parameter are also provided where available.

The criteria and conventions used in generation of these statistics are as follows:

- Only datasets that had at least 20% "detections" (positive result, with value above the method detection limit), and at least three "detections", were included;
- For data sets that met the selection criteria, if a parameter was a "non-detect", i.e., under the method detection limit, it was included in the dataset as half the method detection limit.

Thus, absence of a plot for a specific station for a given parameter may indicate that the dataset did not meet the selection criteria. However, in some situations it may indicate lack of data (due to logistical constraints related to sampling activities). The reader is referred to Table 4-3 and to the summary tables for data inventory information.

Figure 4-1a shows the 1998-99 total suspended solids (TSS) data. Samples collected at the LA. River at Wardlow had the highest median and mean concentrations of suspended solids, and showed the widest distribution (i.e., highest variability) in concentrations. The same station (LA. River at Wardlow) also had the highest median and mean concentrations of suspended solids in the five-year cumulative data set, as shown in Figure 4-2a.

Comparison of the various panels for metals in Figure 4-1 and Figure 4-2 brings up the following observations:

- Stations that peaked in a certain parameter in 1998-99 did not necessarily peak in the five-year data set, for example, highest total copper concentrations in 1998-99 were seen at Ballona Creek (Figure 4-1c), whereas LA. River at Wardlow had the highest median and mean concentrations of total copper over the five-year period (Figure 4-2d);
- Different parameters peaked at different stations, both in the one-year and the five-year datasets. In other words, there was no apparent trend of "cleaner" versus "less clean" watersheds (except for Malibu Creek which appears to have lower bacterial counts than other creeks, consistently for all four groups of bacteria).
- There were several individual exceedances of water quality objectives, either of the California Toxics Rule or of the Ocean Plan (or of both), for total metals; however, the only heavy metal that had a seasonal mean or median exceed an objective was dissolved copper. Further, except for dissolved copper, there were very few individual exceedances of dissolved metals, which are the form of heavy metal that are considered bioavailable (and therefore potentially toxic).

The Permit states that if a given constituent is not detected in at least 25% of the samples taken in ten consecutive storm events at a given station then that constituent may qualify for removal from the analytical suite for the associated station. Several mass emission stations meet this criterion for specific constituents and are summarized in Table 4-6. It is recommended that these constituents be removed from the analytical suite for the associated stations.

4.2.2.3 River Toxicity

As partial fulfillment of the monitoring requirements mandated by NPDES Permit No. CAS614001 from the California Regional Water Quality Control Board (Los Angeles Region). tests were conducted for toxicity of samples of dry and wet weather flow from the Los Angeles and San Gabriel Rivers. The methods of the tests are discussed in Section 3.4, River Toxicity Tests.

Dry Weather Toxicity Results

Sea urchin fertilization was significantly reduced by exposure to the dry weather sample from the Los Angeles River (the 50% concentration had 64% of the eggs successfully fertilized), but no toxicity was detected for the San Gabriel River (the 50% concentration had 99% fertilization) (Figure 4-3). The NOEC for the Los Angeles River was 25% sample, which represents 4 chronic toxicity units (TU_c=100/NOEC). A NOEC could not be calculated for the San Gabriel River since there was no significant reduction in fertilization. Since samples from neither river caused a 50% reduction in fertilization, an EC_{50} could not be calculated (Table 4-7).

A summary of the fertilization counts for each sample concentration is included in Appendix D. The control seawater fertilization percentage averaged 94% and the 50% brine control averaged 97%, well above the minimum acceptable value of 70%.

The results of water quality measurements are shown in Table 4-8. The pH, dissolved oxygen, salinity, and ammonia content of the samples were within acceptable ranges.

The reference toxicant test produced a fairly typical dose response. An EC_{50} of 52 µg/L was calculated for these data which is within the range for an acceptable test (3.2 to 52.4 µg/L).

Wet Weather Toxicity Results

No toxicity was detected in the wet weather sample from San Gabriel River in November (Figure 4-4). Since there was no reduction in fertilization caused by this sample, neither a NOEC nor an EC_{50} could be calculated (Table 4-9). No toxicity was detected in the wet weather sample from San Gabriel River taken in January (Figure 4-5). Since there was no reduction in fertilization caused by this sample, neither a NOEC nor an EC_{50} could be calculated (Table 4-9).

Sea urchin fertilization was significantly reduced by exposure to samples from the Los Angeles River for both storms in (Figures 4-6 and 4-7). The greatest toxicity was present in the March 15 storm sample. The NOEC for this storm was 12.5%, which represents 8 chronic toxicity units (TU_c=100/NOEC). The March 20 sample had a NOEC of 25% (4 TU_c). The EC_{50} for the first storm was 24% sample. Since the sample from the second storm did not cause a 50% reduction in fertilization, an EC_{50} could not be calculated (Table 4-9).

All of the experiments met the test acceptability criteria. For the San Gabriel River sampling, the control seawater fertilization percentage averaging 89% and 91%, respectively and the 50% brine control averaged greater than 99% and 98%, respectively, well above the minimum acceptable value of 70%. The Los Angeles River samples also had good control results with the seawater control averaging 89% and 100% respectively and the 50% brine control greater than 83% and 100%. Summaries of the fertilization counts for each experiment are shown in Appendix D.

The results of water quality measurements are shown in Tables 4-10 through 4-13. The pH, dissolved oxygen, and salinity of the samples were within acceptable ranges for all of the experiments. Total ammonia in the San Gabriel River (3.51 mg/L in November and 2.01 mg /L in January) wet weather samples was elevated relative to the controls, but was well below the level (>20 mg /L) that would be expected to cause toxicity in the sea urchin fertilization test.

The copper reference toxicant tests conducted with each experiment also met performance standards. The EC_{50} values for these tests ranged from 19-48 μg/L, which are similar to the historical average for our laboratory (27.6 μg/L). The data for all four of the tests are within the range for an acceptable test (4.2 to 51.0 μg/L) (Appendix D). The relatively high EC_{50} for the March 22 experiment may indicate a somewhat less sensitive test than we would normally achieve.

4.2.2.4 Bacterial Trends for Sequential Years

Background

The Los Angeles County Program has been monitoring a selection of bacterial indicators, including total coliforms and fecal bacteria (fecal coliforms, fecal streptococcus, and fecal enterococcus), since the 1994-95 rainy season. These fecal bacteria are normal residents of the digestive tracts of humans and other warm-blooded animals. They are usually not pathogenic themselves but they can serve as indicators for the presence of potential pathogens (including bacteria, viruses, and protozoa that may cause human health problems) if contamination of surface waters with sewage had occurred.

Because microorganisms have a limited variety of shapes and forms, they are often defined and sorted by their ability to utilize foods and to withstand harsh environments. To count their numbers, surface water samples are serially diluted into selective growth media and the growth features are observed. Each medium provides a specific food source for the desired microorganism, and/or provides for exclusion of other microorganisms by the use of inhibitors, antibiotics, or restrictive temperatures. As a classification, coliforms include all aerobic and facultatively anaerobic, gram-negative, non-spore forming bacilli that, when incubated at 35^{o}C, ferment lactose and release CO_2 gas within a 48-hour period (APHA 1995). A higher incubation temperature (44.5^{o}C) and a specialized growth medium (with bile salts) differentiate fecal coliforms (FC) from total coliforms (APHA 1995). Thus, fecal coliforms are a subgroup of the total coliform group. Streptococcus and enterococcus have spherical cells and different biochemical features.

Fecal coliforms, fecal streptococcus, and fecal enterococcus are three independent residents of the guts of warm-blooded animals, and their distribution among species varies. Unfortunately, none of them is totally specific to humans, so none can serve as the ultimate indicator and warning signal for the presence of potential human pathogens.

Results

Total coliforms and fecal bacteria (fecal coliforms, fecal streptococcus, and fecal enterococcus) were detected in all samples tested, at densities (or most probable number, MPN) between several hundreds to several million cells per 100 ml. Testing for fecal enterococcus was performed only for selected samples. Figures 4-8 through 4-11 show the wet-weather sample results obtained between 1994 and 1999 for the different bacterial groups (these data are also represented in Table 4-14). The geometric mean (labeled as "log mean" for consistency with reports from other LA agencies) for each storm season is shown as one bar. Results are shown for the four mass-emission stations tested. Malibu Creek appears to have lower counts than other creeks, consistently for all four groups of bacteria. There is no apparent pattern of differences between monitoring years, although the 1995-96 season appears to have higher mean densities than other years.

A study of the raw microbial data for wet weather and dry weather, as presented in the appendices of the 1996-97, 1997-98, and 1998-99 annual reports, indicated the following:

- Densities observed during the first storm of each rainy season were not necessarily higher than during consecutive storm events, suggesting that there was no apparent "first-flush" effect in these watersheds. Peak densities were observed at different times each year.
- Except for somewhat lower densities at Malibu Creek, there was no seasonal or regional consistency in cell densities. There was a very wide range of densities for all stations.
- There was one storm event, January 9, 1998, that yielded extremely high counts in all stations for all bacterial strains. The available data do not provide an explanation, or suggest whether this could be a contamination artifact.
- The 1996-97 season had one event, November 21, 1996, that yielded runoff with high counts in all stations for all species.
- During the 1998-99 season, the event of March 15, 1999 was associated with high bacterial counts for most stations and the events of March 25, 1999 and April 4, 1999 were associated with unusually low counts for most stations.
- Dry weather flows contained bacteria at much lower densities (three to four orders of magnitude lower) than wet weather flows.

These observations, which have not been tested statistically at this time, generate questions that can be addressed by further analysis of existing data. To find whether high densities of one species are associated with increased presence of others, it is recommended to test the correlation between species. High total coliform density may not be necessarily associated with high fecal coliform, because the total coliform group includes bacteria that can live and multiply outside the bodies of warm-blooded animals. On the other hand, fecal coliforms (FC) and fecal streptococcus (FS) both originate from warm-blooded animals. However, they may indicate input from different species (in fact, FC/FS ratio has been suggested as a measure of human contribution but over the years empirical results have shown that this ratio has limited predictive value). Another question, whether peak bacterial densities are observed in different stations at the same time (and therefore may be related to regional hydrologic conditions) can be addressed simply by plotting bacterial counts as a function of time for each station.

4.2.2.5 Loadings for Constituents of Concern for Sequential Years

Derivation of Event Mean Concentrations

Section B.4 of Attachment C of the Municipal Stormwater Permit (CAS614001) requires the County to perform a loads assessment analysis for each of the six Watershed Management Areas to determine pollutant loads entering the ocean from receiving waters in the county . . . using the collected monitoring data from the land use and mass emission stations . . . and employing the USEPA simplified model. The work plan for this assessment, submitted to the Regional Board on November 6, 1997, was described in detail in *Monitoring Task Report No. 2* (Woodward-Clyde, December 9, 1996b). Loads from monitored mass emission watersheds have been calculated from observed mass emission mean concentrations and runoff volumes. Loads from unmonitored watersheds have been estimated using the GIS loading model with mean concentrations derived from the land use monitoring program. Following is a brief explanation of how event mean concentrations were calculated.

The event mean concentration is based on flow-weighted composited samples. Numerous data sets were created comprised of laboratory results from each monitoring station for a given season. Data were screened and analyzed to determine the quality and amount of data present. The following criteria were applied:

- at least 20% of the sample results were detected concentrations;
- there were at least 3 detected sample concentrations.

If the set of data did not meet these criteria, it was not used to calculate an event mean concentration. If sufficient data existed to conduct the statistical analysis, two methods were followed to address non-detects.

Initially, the Hazen robust method was used to calculate land use EMCs. The robust method uses a combination of regression and probability analysis to determine the "assumed" concentration to assign to samples with concentrations below the method detection limit. The "assumed" concentration is the point along a probability distribution regression line (derived from detected data) where true concentrations of non-detected data have the highest probability of residing. Each non-detect result was assigned the value of the detection limit and ranked along with the other detected results in the data set. The cumulative frequency data were plotted on a logarithmic plot and a straight line regression was fitted to the points. The mean, m, and variance, s^2, of the natural logarithm of each point of the data set were used to calculate the event mean concentration. The event mean concentration, which the loading model multiplies by the volume of the event runoff to develop total loading, is defined as follows:

$$\text{Event Mean Concentration} = \exp(m + 0.5s^2).$$

In order to reduce analysis time, another method, which has been successfully implemented by other agencies, was also used to calculate EMCs for the mass emission water quality data. That second method assigned a value of half the detection limit to each non-detect result. The resulting data set of concentrations was analyzed as described above to develop the mass emission EMCs. A comparison of the two methods showed that differences between EMCs developed from the same data set were insignificant in most cases; therefore, the second method assumed a valid approach.

The calculated EMCs are summarized in Tables 4-15a through 4-15e for specific land uses. These EMCs were used to estimate loadings for several watersheds.

The loadings calculated for the monitored watersheds are summarized in tables 4-16a through 4-16f and in Figures 4-12 through 4-18. TSS loadings for each watershed are graphically depicted for each season monitored since 1994-95 (Figure 4-12). Other constituent loadings are summarized for each season in each monitored watershed (Figures 4-13 through 4-18).

The locations of unmonitored watersheds are shown in Figures 4-19 through 4-21. The loadings calculated for the unmonitored watersheds are summarized in tables 4-17a through 4-17c and in Figures 4-22 through 4-25. TSS loadings for each watershed were modeled and are graphically depicted for each season since 1994-95 (Figure 4-22). Other constituent loadings were modeled and are summarized for each season in each unmonitored watershed (Figures 4-23 through 4-25).

4.2.3 Land Use Element

The land use element monitoring results for the 1998-99 season are summarized in Table 4-18 while cumulative results for 1994-99 are summarized in Table 4-19. These tables include the number of samples analyzed and the percentage of samples that had detectable concentrations, as well as summary statistics (the mean, median, and coefficient of variation (CV)). Box and whisker plots for several constituents are included as Figures 4-26a through 4-26h for the 1998-99 season and as Figures 4-27a through 4-27g for 1994-99. All data for land use monitoring stations are presented in Appendix C.

The median pH values were visibly different between catchment types, and this trend is also reflected in the median concentrations of bicarbonate. Runoff from the vacant catchment had high pH (8.5) and high alkalinity (median of 175 mg/l), while runoff from the light industrial, transportation, and mixed residential stations had lower median pH values(6.9, 6.9, and 6.8 respectively) and lower median alkalinity concentrations (22, 18, and 16 mg/l respectively). The commercial station fell in between these two extremes with a median pH of 7.6 and a median alkalinity of 76 mg/l.

Hardness is also an important variable of water quality because it diminishes the potential of dissolved metals to cause toxicity to aquatic life. Median hardness concentrations follow the alkalinity pattern: high (190 mg/l) at the vacant station; low in the light industrial (35 mg/l), transportation (30 mg/l), and mixed residential stations (24 mg/l); and in between (134 mg/l) at the commercial station.

Total suspended solids (TSS) measurements reflect the amount of sediment in the water. Sediment is a constituent of concern because of the potential to adversely affect the aquatic habitat and also cause sediment accumulation that ultimately may require dredging. Sediment also may be a carrier of other chemicals that have a tendency to adsorb to particulate matter. TSS results overlapped substantially among the different land uses, however the range of values was larger for the mixed family residential, commercial, and light industrial stations in the 1998-99 season. The light industrial station had the highest mean and median for TSS (152 mg/l and 157 mg/l) being approximately twice as high as the next highest mean and median (86 mg/l and 40 mg/l for multi-family residential).

Metals in stormwater runoff can be of concern because some metals are toxic to aquatic organisms and some can bio-accumulate in the tissues of aquatic organisms (e.g., fish and clams) and be a human health concern. Total and dissolved copper concentrations overlapped among the different land uses, however the range of values was larger for the transportation station in the 1998-99 season. The cumulative pattern is similar except that larger ranges are observed at both the light industrial and transportation stations for total copper. Dissolved copper generally exceeds the 4.8 µg/l California Toxics Rule guideline while total copper exceeds the Ocean Plan guideline more frequently in the commercial, light industrial, and transportation stations. Total lead results are fairly consistent among land uses both in the 1998-99 season and cummulatively with a couple of higher observations at the commercial and light industrial stations. Dissolved and total zinc exhibit similar patterns for both the 1998-99 season and the cumulative data. There is substantial overlap among the different land uses although the mean and median for the light industrial station is highest in each case.

Bis(2-ethylhexyl)phthalate was observed at all land use stations over time. The vacant and multi-family residential stations had higher means than other stations this season, but cummulatively observations overlap substantially. Means and medians for all stations exceed the Ocean Plan standard in the cummulative data set.

Diazinon was observed in 43% of the mixed residential samples and 25% of the commercial samples this season. Due to a lowering of the detection limit from 0.25 µg/l to 50 ng/l, this was the first storm season diazinon was observed in this monitoring program. The detection limits were lowered at the request of the Regional Water Quality Control Board.

The Permit states that if a given constituent is not detected in at least 25% of the samples taken in ten consecutive storm events at a given station then that constituent may qualify for removal from the analytical suite for the associated station. Several land use stations meet this criterion and are summarized in Table 4-20. It is recommended that these constituents be removed from the analytical suite for the associated stations.

The Permit allows the discontinuation of monitoring at a land use station for specific constituents once the event mean concentration (EMC) is derived at the 25% error rate. We used the mean standard error as a substitute for error rate as mutually agreed upon with the RWQCB (Swamikannu, 1999).

The constituents evaluated include:

- PAHs
- Chlordane
- Cadmium
- Copper
- Nickel
- Lead
- Chromium
- Silver
- Zinc
- Selenium
- Mercury
- Total Nitrogen
- Total Phosphorus
- TSS
- Diazinon
- Chlorpyrifos
- Malathion
- Simazine
- Total DDTs
- Total PCBs

We first identified 115 station-constituent combinations which had at least 10 detected samples and no more than 20% non-detected samples. Non-detects were replaced with half of the corresponding detection limit. Then, we performed the Shapiro-Wilk Normality Test at 5% significance level on each station-constituent to determine whether the concentrations were normally or lognormally distributed (Gibbons 1994, USEPA 1995). If the p-value of the normality test in raw scale of the constituent's concentration was greater than 0.05, such station-constituent was concluded to be normally distributed. Similarly, if the p-value of the normality test in log-transformed scale was greater than 0.05, it was concluded to be lognormally distributed. If a station-constituent was determined to be both normally and lognormally distributed (the p-values for both tests for normality were greater than 0.05), we assigned such station-constituent with a normal distribution. Similarly, if a station-constituent was neither normally nor lognormally distributed based on the normality tests (both p-values less than 0.05), we assumed that it had a normal distribution.

Based on the probability distribution determined above, we calculated the mean standard error as follows:

$$\text{Mean Standard Error} = \frac{\text{Standard Error}}{\text{Mean}} = \frac{\text{Standard Deviation} / \sqrt{\text{Sample Size}}}{\text{Mean}}$$

For those station-constituents with a normal distribution, the sample mean and standard deviation were used in the above formula. However, for station-constituents with a lognormal distribution, the mean and standard deviation were estimated as follows (Gilbert 1987):

$$\text{Mean}, \hat{m} = e^{(\bar{y}+\frac{s_y^2}{2})}$$

$$\text{Standard Error}, s(\hat{m}) = \sqrt{e^{(2\bar{y}+\frac{s_y^2}{n})}\left[\left(1-\frac{2s_y^2}{n}\right)^{-\frac{(n-1)}{2}} \cdot e^{(\frac{s_y^2}{n})} - \left(1-\frac{s_y^2}{n}\right)^{-(n-1)}\right]}$$

where $\bar{y}$ and s_y^2 are the arithmetic mean and variance of the log-transformed values

n is the sample size

All results of this analysis are summarized in Table 4-21. Of 115 station-constituents under investigation, 39 of them had an EMC with a mean standard error higher than 25%. In other words, there were 39 station-constituents which had a standard error (standard deviation of the mean) larger than 25% of their corresponding mean concentrations. These station-constituents must continue to be monitored under the current Permit. The remaining 76 station-constituent combinations met the criteria and it is recommended that monitoring be discontinued for these constituents at the associated stations.

4.2.4 Critical Source Element

Following is a discussion of the results of the 1998-99 critical source study along with comparisons to mass emission and commercial, light industrial, and transportation (CIT) land use category pooled results (see Tables 4-22 and 4-23). Comparisons to last year's critical source results are also included. Please refer to Table 4-24.

The comparisons were made to find if major variations exist between the runoff from the critical source study sites and the mass emission and (CIT) land use stations. The reasoning is that if there is no observable difference between the mass emission, CIT, and critical source study results, then these sources may not in fact be "critical" in the sense of requiring implementation and testing of the effectiveness of additional BMPs. Further, to date, only dissolved zinc and dissolved copper have been the only metals identified as contributing toxicity to the receiving waters of Santa Monica Bay (SCCWRP, 1998).

Even though the department was not able to install and implement the BMPs at the 1997-98 test sites, a few site owners at the auto dismantling/recycling sites are following various "good housekeeping" practices as part of their own self-monitoring or group-monitoring permit requirements. Since there are no "test" and "control" triads, the critical source runoff results have been grouped together like last year.

Table 4-24 summarizes the mean values of the critical source, CIT pool, and mass emission programs for the 1997-98 and 1998-99 storm seasons. It also includes, for comparison purposes, results from the vacant land use category as well as the water quality "objectives" presented in the California Ocean Plan (Ocean Plan), the Los Angeles Region Basin Plan (Basin Plan), and the California Toxic Rule (Toxic Rule). Results are also shown of the study performed by Swamikannu (1994).

Note there are no numerical water quality standards that apply to stormwater or "non-point source" pollution. Current federal and state standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean and other water bodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation or noncompliance with the plans. The Toxic Rule is, strictly speaking, applicable to industrial and sewage treatment plant point-source discharges, but not to storm water runoff discharges, which do not have any effluent limits. The Ocean Plan objectives apply to "instantaneous" grab samples, and the Basin Plan differs from basin to basin in Los Angeles County. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards is not directly applicable since the results presented in the tables are detected values before dilution, a factor allowed by the Ocean Plan. At the same time, however, it should be noted that new stormwater permits are including the narrative guidelines and limitations prescribed in the local Basin Plans.

The constituents whose mean or median were above the objectives of the Ocean Plan, Basin Plan, or Toxics Rule are discussed below and are as follows:

- Bis(2-ethylhexyl)phthalate (a semi-volatile organic)
- Dissolved cadmium
- Dissolved copper
- Total copper

- Dissolved lead
- Total lead
- Dissolved zinc
- Total zinc

In addition, discussions of aluminum, TDS, TSS, COD, TPH, O&G, specific conductance, MBAS, total organic carbon, and pH are included below.

The testing methods for the critical source program are outlined in Section 4.

Cadmium

For total and dissolved cadmium, the highest levels were observed at the auto dismantler sites (means of 2.7 ppb and 1.5 ppb, respectively), which were below any of the Ocean Plan, Basin Plan, or Toxic Rule objectives. The mean values of the other critical source study sites were below the detection limit (1 ppb). Furthermore, the results for total and dissolved cadmium were below those of the mass emission stations.

Last year's highest values occurred at the auto repair sites (means of 3.5 ppb and 2.8 ppb, for total and dissolved cadmium respectively). Swamikannu's study of similar auto repair sites in Southern California observed mean levels of 9 ppb.

Copper

The fabricated metal sites showed the highest levels of both total and dissolved copper concentrations (means of 500 ppb and 177 ppb, respectively) as compared with the auto dismantler and repair sites. The value for dissolved copper also exceeded the means for the mass emission and CIT stations (5.7 ppb and 21 ppb, respectively). The Ocean Plan objective for total copper is 30 ppb, while the Toxics Rule objective for dissolved copper is 4.8 ppb.

Last year, the highest levels for total and dissolved copper were observed at the auto repair sites (means of 83.6 ppb and 63.6, respectively). Swamikannu's (1994) mean value from a similar auto repair site was 106 ppb.

Lead

The highest concentrations of total and dissolved lead occurred at the fabricated metal sites (means of 113 ppb and 52 ppb, respectively). There were "no meaningful" mean or median values for the mass emission stations, while the CIT stations registered a mean of 6.6 ppb. This year's concentrations were lower than last year's, where the highest levels occurred at auto repair sites (mean of 184 ppb). However, the levels were lower than the Swamikannu's (1994) auto repair sites (mean of 234 ppb). All values exceeded the Ocean Plan objective for total lead of 20 ppb and the Toxics Rule objective for dissolved lead of 50 ppb.

Zinc

Total zinc was observed with the third highest level of total metal concentrations, next to iron and aluminum. Dissolved zinc was the second highest of the dissolved metals, next to iron. The highest dissolved concentration was observed at the fabricated metal sites (mean of 574 ppb) as compared with the auto repair (mean of 221 ppb) and the auto dismantler sites (mean of 311 ppb). Total and dissolved zinc concentrations were higher than both mass emission and CIT stations. In all cases, this year's levels exceeded the Ocean Plan objective of 200 ppb for total zinc and the Toxics Rule objective of 86 ppb for dissolved zinc.

Aluminum

Total aluminum had the second highest concentration, next to total iron, of all metals analyzed this season, with the highest concentrations occurring at the fabricated metals sites (mean of 2434 ppb). (Note that total iron and total aluminum are present in the vacant land use runoff.) The levels were two times greater than the auto repair sites (mean of 1205 ppb) and five times greater than the auto dismantling sites (mean of 449 ppb). The auto repair site had only 79% detected samples while the dismantler and fabricated metal sites had 100% detection. The mass emission stations indicated a mean of 503 ppb. Swamikannu's (1994) auto repair site yielded a mean of 1730 ppb. The Basin Plan objective is 1000 ppb.

Total Dissolved Solids (TDS)

The TDS parameter was analyzed from a composite sample. The highest value was observed at auto dismantler sites (mean of 127.3 ppm) followed by fabricated metal and auto repair sites, and were lower than the CIT levels (mean of 187.4). Swamikannu's (1994) mean value for auto repair sites was 913 ppm while comparable auto repair site mean value under this project was 66 ppm. The Basin Plan objective is 300 ppm.

Total Suspended Solids (TSS)

The TSS parameter was analyzed from a composite sample. The highest value was observed at auto repair sites (mean of 205.8 ppm) followed by auto dismantlers and fabricated metals, and exceeded mass emission levels (mean of 154 ppm). Swamikannu (1994) observed a mean value of 963 ppm at auto repair sites. The Basin Plan objective is 300 ppm.

Chemical Oxygen Demand (COD)

The COD samples were collected during the first flush and analyzed as discrete samples. The highest levels were observed at auto repair sites (mean of 132.8 ppm). Last year's highest levels (mean of 231 ppm) were observed in the auto dismantlers group. The level is higher than the Mass Emission and CIT levels (mean of 62 ppm and 79 ppm respectively). Swamikannu's (1994) repair site had a higher mean value of 291 ppm.

COD is indicative of amount of oxygen required to "break-down," or oxidize, oils and solvents in the water. The greater the level of COD, the greater the suspected amount of dissolved solvents or oils. There is no action limit set for the constituent.

Total Petroleum Hydrocarbon

Total petroleum hydrocarbons can be quantified in several ways (e.g., as gasoline or diesel). Total recoverable petroleum hydrocarbons were analyzed once in 1997-98 and were not analyzed in 1998-99. The 1998-99 samples for TPH analysis were collected as discrete samples during the “first flush.” TPH was not detected as gasoline or diesel. These results compare favorably with the 1997-98 results, which had a high mean of 29 ppm, and may reflect the owners’ voluntary efforts in implementing minimal BMPs to improve their sites. Note, however, that there were no detections of TPH from any of the CIT land use analyses, so the non-detects this year may be more indicative of the smaller rainfall events.

Oil and Grease (O&G)

Oil and grease samples were collected and analyzed as discrete samples. The highest level of oil and grease (mean of 16.7 ppm) was observed from the fabricated metal industry, which is less than Swamikannu’s (1994) findings of a mean of 25 ppm. The oil and grease results were not compared with the mass emission and CIT results because the analytical methods are not the same.

Swamikannu reported that the mean concentrations of O&G at auto dismantling companies ranges from 5 ppm to 38 ppm. The Ocean Plan limit is 75 ppm (at any time) for effluent limitations for sewage treatment plants.

Specific Conductance

Specific conductance, influenced mainly by the presence of metals and total dissolved solids, was analyzed from discrete samples collected during the first flush. The highest result (mean of 249 umhos/cm) was observed at the dismantler sites, while the lowest (mean of 90.1 umhos/cm) was observed at the repair sites. Compared with mass emission and CIT results, the current results fell far below the mean value of 748 umhos/cm. There are no reported values for Swamikannu’s study.

Methyl Butyl Activated Substances (MBAS)

MBAS are analyzed as a composite sample. The highest level was observed this season at the auto repair sites (mean of 0.31 ppm), which is less than the 1997-98 mean of 1.5 ppm. The CIT result was 3.2 ppm; the basin plan limit (0.5 ppm) was not exceeded.

MBAS generally originate from surfactants; the soaps and detergents used in site and parts cleaning. The non-exceedence levels of the critical source study sites could indicate voluntary good housekeeping efforts of the owners.

Total Organic Carbon (TOC)

Total organic carbon was the highest value (mean 31.6 ppm) at auto repair sites during the 1998-99 storm season, which was higher than both the current mass emission and CIT maximum values of 10.0 ppm and 11.75 ppm respectively. This season’s mean value is also higher than that of 1997-98 (mean of 27 ppm).

There are no action limits set for TOC and there are no comparable values from Swamikannu’s study.

pH

The lowest pH level measured (in the laboratory) was 6.2, and the highest was 6.7, as compared with the mass emission and CIT values of 6.8 and 7.7, respectively. Both values are within the same range as Los Angeles County rainwater values. (Air Resources Board, Los Angeles).

Other Metals

Chromium, iron, and nickel were all analyzed from composite samples. The highest chromium level was 15.4 ppm from fabricated metal sites, below levels detected in the mass emission and CIT results; the basin plan objective is 50 ppm.

The highest nickel level had a mean of 90.7 ppm from fabricated metal sites compared with mass emission and CIT values of 20.7 ppm. There are no action limits for nickel.

Total iron was by far the highest of all metals observed. However, its level fell from the mean 4598 ppm to 2726.1 ppm. The former was observed at the fabricated metal shop and the latter at the auto repair sites.

Semi-Volatile Organics (SVOCs)

From all the samples tested for SVOCs, only bis(2-ethylhexyl)phthalate was detected. The highest level was 23.6 ppb, lower than 1997-98's highest level of 52.8 ppm. There are action limits for the constituent. The constituent, a plasticizer, occurs as a laboratory contaminant and is also found in pumps; however, there are no pumps used at the facilities to retrieve critical source samples. It is possible it may be traced to the laboratory analytical procedure, or from the plastic dippers utilized in collecting the water samples.